SOME ASPECTS OF FREE-AIR WINDS IN THE FAR WEST

By THOMAS R. REED

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At the beginning of the present year (1932) a noteworthy improvement was made in the system of reporting and collating the results of pilot-balloon observations in the United States. Previously the datum point for each wind level reported had been the level of the observing station instead of a common level. Since January 1932 a common level has been used, namely, sea level. The result is greater uniformity, or at least, greater consistency, of the reported data. Doubtless the effect of the change was most appreciated by users of the data in the Far West where the mountainous character of the terrain produced a marked "staggering" of levels under the old system.

Take, for example, the reported data for a given level, say 4,000 m. In the past such data in the form available for entry on the aerological charts actually approximated wind conditions at that height above those stations only which were situated near sea level. For elevated stations such, let us say, as Reno, Salt Lake City, or Rock Springs, the data, ostensibly for the 4,000-m level, actually represented wind movements at much higher levels, viz, 5,346 m, 5,294 m, and 5,953 m, respectively. Hence the forecaster, endeavoring to interpret the atmospheric situation in terms of air streams was constrained to make allowance for such inconsistencies in forming his estimate of the circulation factor so far as it was revealed by the wind-aloft reports. That the key to the meteorological situation is frequently contained in these reports is beyond argument; hence the importance attaching to their accuracy can hardly be overstated.

Pilot-balloon runs as an aid to forecasting have been systematically made in the Far West since their inauguration at San Francisco about 12 years ago. The Army and Navy added their cooperation soon after with runs at San Diego, Sacramento, and Camp Lewis, and the Weather Bureau later on added other stations to the list, but a complete network of pilot-balloon stations was not realized west of the Rocky Mountains until the Airways Weather Service came into existence with its elaborate program of upper-air soundings in behalf of aviation. These observations, primarily designed as an aid to aerial navigation, have been of great value in the work of weather forecasting, too. To the forecaster they are an invaluable guide in his day-to-day tasks, and in addition they have an educational aspect that is not to be ignored. They serve to disabuse him of incorrect opinions that he may have entertained, and to enlighten him regarding atmospheric events of which he may have been unaware or perhaps only vaguely conscious.

An illustration in point may be found in the simple and well-known rule that southerly winds (on the Pacific slope) bring rain. This precept shows deference to the formal requirements of widely accepted ideas such as the "warm front" and "convergent current" hypotheses. Both postulate a southerly current near the surface in front of eastward moving cyclones, and both of course assume it to be composed of rising air. In one view the southerly current ascends by reason of overrunning a wedge of colder air in its path; while the other view supposes ascension to result from convergence of lines of flow in the southerly current, itself. Touching the latter, Shaw is not sure whether the convergence is the cause or the result of the ascending current but is "content to know that convergence cannot occur unless there is an upward current to take off the air." [1] The absence of a cold wedge (east wind) in advance of cyclone centers off our west coast is a fact of common observation. The surface temperatures in the region of the broad rain band are mild and remarkably uniform, and winds everywhere from a southerly quarter except where required by topography to be otherwise.

In the Bjerknes theory the south wind is not a rain wind until it leaves the surface and rides up over a denser westward flowing current athwart its path. Hence this theory fails to account for the fact that a southerly surface wind is a rain wind on the Pacific coast. As for the alternative possibility—convergence—the balloon observations fail to reveal it at all. Aerological data show that a southerly surface wind is a rain-bearing wind only in the sense that it may and often does imply a west or southwest wind aloft—a fact which points to the conclusion that reduction of pressure aloft and consequent upwelling of the lower strata, rather than convergence of air streams below, is responsible for the ascent of air in the rain-making sector of the warm front. They seem to support with a good deal of consistency the view that the apparent vortex and inflowing winds of the lower cyclone levels are incidental to divergent air streams aloft, one flowing down from the north, and the other flowing up from the south *and veering toward the east with increase of altitude.*

It is in this region of divergence that the pressure falls, because it is in this region that air is being evicted by the eastward-veering winds aloft. Hence it is superfluous to appeal to convergence or to topography for the explanation of the ascension of the southerly surface air; it is compelled to rise by the eviction of air aloft. That topography plays an important (though far from all important) part in rain production on the Pacific coast is admitted, but if we look to topography alone for an explanation of the rain-making propensities of the southerly wind we shall err, for southerly winds run parallel to the main mountain ranges instead of counter to them, so that unless the winds above are turning toward the east, a southerly wind, by reason of the deflective force of the earth's rotation, brings about a rise in pressure along the west side of the mountain ranges instead of bringing about a fall. Furthermore, reports from ships at sea show the southerly wind to be a rain wind but without the circumstance of topography to aid it; the veering or divergence aloft of the two principal air streams involved is sufficient in itself to account for the observed phenomenon of rising air and rain.

It has often been observed that when the south wind does not veer toward the east aloft, the pressure falls very slowly, if at all, and rain is a rare consequence. This observation has so few exceptions as to make the following precept worthy of consideration, namely, that not convergent but divergent winds (in the upper levels) are an essential of the rain-making process in front of Pacific Ocean LOWS. Or, to put it more exactly, but still in general terms, the commonest type of rain-making regime on the Pacific coast requires on the west side of the cyclone a more of less "solid" northwest or north-northwest current up to considerable altitudes, and on the east side of the cyclone a southerly current that diverges toward the east with increase in height.

[1] Shaw, W. N. Forecasting Weather, 2d edition, p. 241.

Also, the proverb that a south wind brings rain, might well be supplanted by the more accurate statement that it is the west wind which brings the rain; for both the rain and the southerly surface wind which attends it are, in a sense, by-products of the falling pressure for which the westerly current aloft is directly accountable.

While the foregoing applies with fewest exceptions to elliptical or trough-shaped depressions, it is germane to depressions of nearly all types, provided they are of large area. It does not seem to apply to many small depressions which sometimes form over the Far West and which present the aspect of a vortex up to the highest level sounded by the aerological net, viz, 14,000 feet. Counter currents do not appear to be accountable for their formation or maintenance; at least none are evident up to the height mentioned. What transpires above is conjectural, but the fact that the cyclonic circulation in such cases is always observed at the high levels prior to the development of falling pressure and unsettled weather at the surface certainly points to the general hypothesis that cyclones of the Far West are of high level origin, although it does not explain how those which appear as a vortex at 14,000 feet above sea level were generated.

But not all small depressions present a vortical circulation aloft. Those, for example, which sometimes appear off our southern coast are also often conspicuously identified with west or southwest winds in advance of them, i. e., over Arizona and New Mexico, but instead of the air current in their rear being from the northwest or north-northwest as in the case of large eastward moving cyclones of higher latitudes, the free-air winds are often from the north-northeast. Cyclones of this type are accompanied by high pressure at sea to the northward, the main axis of the anticyclone lying in a northeast-southwest direction with the cyclone on its equatorial side. It is important to note that so long as the upper winds in the northeast quadrant of such a cyclone continue to blow from the northeast or north-northeast, the disturbance lingers off the southern California coast (either the original one or a successor); whereas as soon as the winds referred to lose their east component and veer to the north and northwest, the cyclone moves eastward and the weather in southern California clears.

Mr. R. H. Weightman, whose helpful comments on this paper when in manuscript form deserve acknowledgment, remarked in this connection that "European writers have found, and it has been substantiated by our studies here (Washington, D.C.) that the movement of LOWS is more directly associated with air currents between 500 m and 2,500 m in the eastern half of the LOW, than with those in the western half, especially when the LOW has a warm sector." This is precisely what one would expect of low-level cyclones moving over a not too mountainous terrain. For our ultramountainous West it does not apply, and forecasters in the Far West are compelled to depend on wind data around the 4,000 m level for the most reliable clues of storm travel.

Examples like the foregoing, illustrative of the part played by the two great air streams—the north and the west—merely stress familiar facts, but facts important enough, perhaps, to bear repetition, and whose reiteration may even now be helpful in stressing the fact that it is the flow of air currents and their interaction which are our primary concern, rather than surface phenomena. In the "great rivers of air" over our heads, to borrow an expression of Maj. E. H. Bowie, is to be found the answer to the weather forecaster's most pressing problems; and while these rivers are often to be inferred from the isobaric patterns on the synoptic charts, the balloon data frequently serve to bridge over the inferential gap and acquaint the forecaster directly with much that he needs to know.

In the plotting and anticipation of these rivers of air, so important to the success of short-period weather forecasting, must we not ultimately find, if it is found at all, the key to the greater problem of long-period forecasting? Weather types are essentially air-flow types, and the persistence of a weather type is consequent upon the persistence of an air-flow type. The recent cold and snowy winter (1931–1932) in the Pacific States is an example. It was prolific of depressions which appeared in the far North or Northwest and moved southward along or near the Pacific coast. Obviously the controlling air currents, of which the depressions were peripheral phenomena, were persistently from a north or northwest quarter and constituted a very extraordinary south or southeastward movement of air over the northeast Pacific Ocean during the wettest part of the winter. A survey of synoptic charts and pressure graphs for this period confirms this inference in the persistence they show of high pressure offshore and low pressure over the far western portions of the United States and Canada. The Pacific coast seemed, much of the time, to lie in a "low-pressure lane" created and maintained by the southward flowing aerial river immediately to the westward.

In contrast to this was the excessively dry fall and winter of 1929–30. During the dry part of the period the reverse of the foregoing situation with respect to air streams evidently prevailed. Charts and pressure graphs showed a marked preponderance of high pressure over the far western portions of the United States and Canada, and about the usual amount of low pressure, if not more, at sea—clear evidence of a dominating flow of air from the south or southwest along and off the Pacific coast, which prevented disturbances from moving inland and carried them northward instead. The "low-pressure lane", to the extent which any existed, lay necessarily on the west side of this current, leaving the Pacific States and British Columbia in a dry zone so long as the aerial river, which was responsible, persisted in the position and course described.

THE RELATION OF JUNE TEMPERATURE TO THE MATURING OF CORN IN IOWA

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[Author's Abstract]

The extent of autumn frost damage in Iowa is largely determined by the mean temperature of the previous June. In every one of the 12 cases when the June mean temperatue was 2°, or more, above the average, 69.4°, during the 43 years from 1890 to 1932, 95 percent, or more, of the corn escaped frost damage.

In 21 years out of 22, with June mean temperature normal, 69.4°, or higher, the percentage of corn not frosted was greater than the 43-year average of 87.3 percent. Except in 1923, when 75 percent was not frosted, 90 percent, or more, escaped frost damage in all of the 22 years.

A June mean temperature of 67° (2.4° below the average of 43 years) roughly divides the years in which 90 percent, or more, of the corn matured safely, from those having the most serious frost damage. Thirty-two Junes had temperatures above 67°, and in 29 of them 90 percent, or more, of the corn escaped frost.